# Mock data: example

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# Outline

- The goal of this talk is to describe the steps required to perform a mock data study
- The focus is on demonstrating the capabilities of a particular ND subsystem, i.e. the HPgTPC
- I haven't done the study, so there are no actual results, but hopefully you will see these slides and be inspired to think about how to build the physics case for your favorite detector

# Mock data step by step

- Step 1: Create mock data sample
- Step 2: Fit sample with FD-only, determine oscillation parameters
- Step 3: Make specific distributions of “reconstructed” events in a near detector, for mock data and nominal model
- Step 4: Demonstrate that the discrepancy can be resolved with ND, bonus points if you can show not only that the $\chi^2$ is bad, but highlight specifically *where* the discrepancy is

# LBL collaboration with NDDG


**CAN HELP MAKE THE PHYSICS CASE FOR THE ND**

- The LBL group has developed a suite of tools that can be used to do oscillation fits & sensitivity studies
- The LBL group can help you use these tools to perform studies to motivate ND subsystems
- But the LBL group is not going to think up studies to motivate the 3DST – we need input from the 3DST group

# What you need to provide to do a study

- Input #1: Event-by-event weights to produce desired mock data
  - Can be based on a specific model variation, i.e. MK single pion production model
  - Can be based on a totally different generator, i.e. NuWro, with weights generated by Cris V's tool
  - Can be totally made up, i.e. increase CC2π and decrease CC3π to preserve total XS vs. Ehad

# What you need to provide to do a study

- Input #2: ND reconstruction & event selection
  - LAr pseudo-reconstruction exists and can be easily used
  - GAr pseudo-reconstruction semi-exists
  - Or you can provide your own map from simulated events → reconstructed quantities
- File format is “CAF” and LBL group can help you make CAFs from your reconstructed files – tools exist to convert edep-sim to CAFs

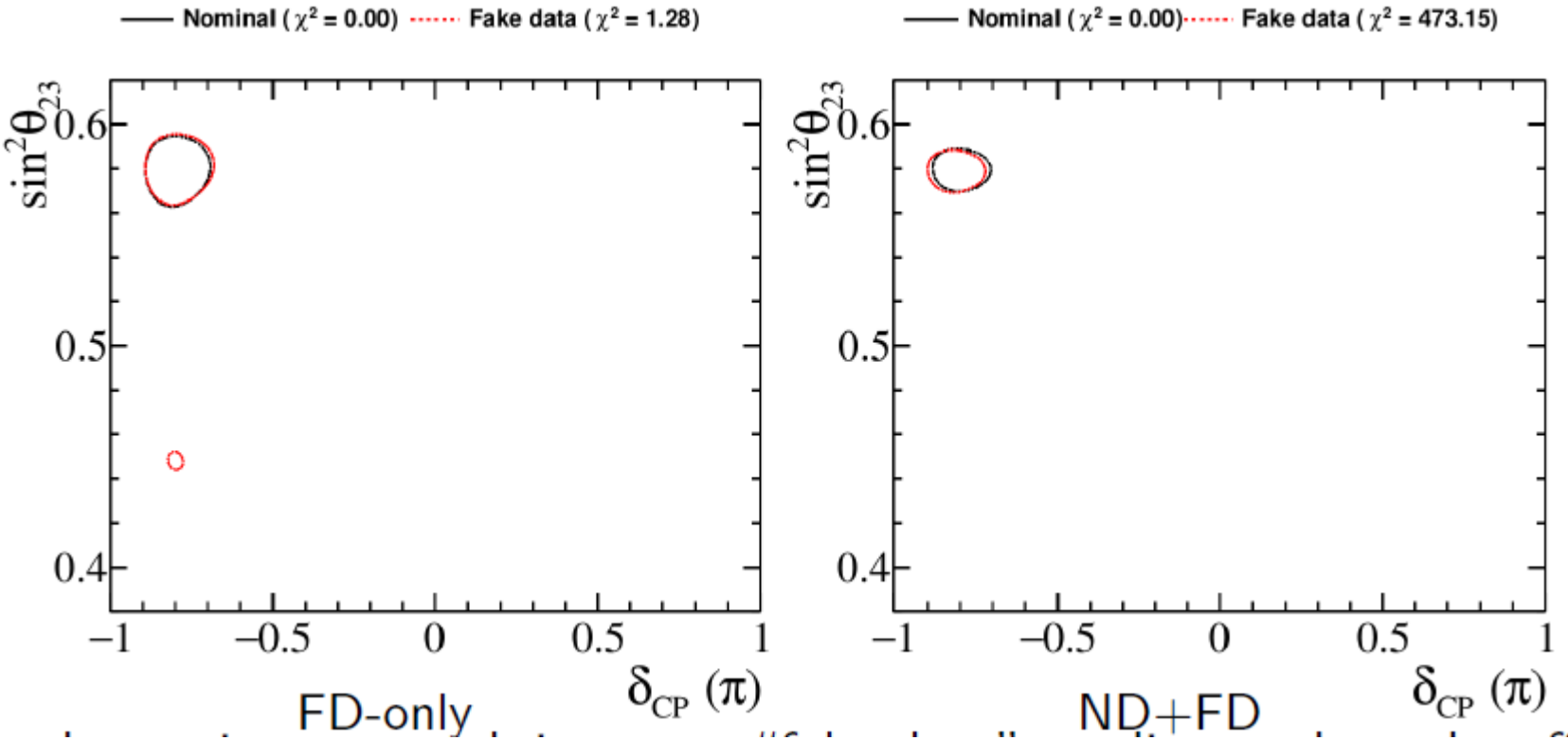
# What you need to provide to do a study

- Input #3: ND distributions to demonstrate effect
  - FD TDR fit LAr ND in ($E_\nu$, y), but many things will show up better in other spaces, i.e. (q0, $q_3$)

# What you need to provide to do a study

- Input #3: ND distributions to demonstrate effect
  - FD TDR fit LAr ND in ($E_\nu$, y), but many things will show up better in other spaces, i.e. ($q_0$, $q_3$)
  - Mock data sample could be motivated by a specific measurement that can be made with high precision, i.e. number of protons for HPgTPC

# MD motivated by specific model variation




- Shows impact on oscillation parameters of fitting to MK single pion production model
- Impact of individual tweaks, which affect only a subset of events, may be somewhat small

# Step 1: build the mock data

- Consider as an example for HPgTPC
- Example: Weight up CC3π, and weight down CC2π, such that the total rate stays constant as a function of Ehad
- CC2π and CC3π have different Eν → Erec maps, so this will modify the reconstructed energy at the far detector
- LAr ND might struggle to isolate these samples, but HPgTPC can do it cleanly

# Step 2: Fit FD-only

- Create a “knob” in the CAF for this shift
- Fill the weights
- Add the knob in CAFAna and turn it on
- Run a FD-only fit
- Run LAr ND+FD fit
- LBL experts can help with these steps

# Step 3: Reconstruct events

- Reconstruct the HPgTPC events
  - Could use pseudo-reconstruction & CAF maker developed by Tanaz, Justo, CM
  - Could use garsoft + CAF maker
- Produce CAF files for the HPgTPC, including the reweight knob from before

# Step 4: Make HPgTPC distributions

- HPgTPC can resolve CC2π and CC3π separately
  - Low pion thresholds
  - Excellent π/p PID up to ~1 GeV/c
- Maybe flux-integrated leading and sub-leading pion energy distributions for the two samples
- Show that you can tell that the relative normalizations of the two samples is off

# Conclusions

- Think about specific shifts and reconstructed samples that illustrate a strength of your favorite detector
- Reach out to LBL group on #physics-lbl or #cafana for help with producing inputs, running fits, etc.
- Or email LBL conveners, who will direct you to a relevant expert